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SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

Demonstration Bulletin

High Voltage Electron Beam Technology

High Voltage Environmental Applications, Inc.

Technology Description: The high voltage electron beam (E-beam) technology was developed by High Voltage Environmental Applications, Inc. (HVEA), to destroy organic compounds in liquid wastes. This technology irradiates water with a beam of high-energy electrons, causing the formation of three primary transient reactive species: aqueous electrons, hydroxyl radicals, and hydrogen radicals. Target organic compounds are either mineralized or broken down into low molecular weight compounds primarily by these species.

Figure 1 shows a schematic of the HVEA E-beam system (model M25W-48S). The system is housed in an 8- by 48-ft trailer and is rated for a maximum flow rate of 50 gal/min. The E-beam system includes the following components: a strainer basket, an influent pump, the E-beam unit, a cooling air processor, a blower, and a control console not shown in the figure.

After particulates are removed from the influent by the strainer basket, the influent pump transfers contaminated water to the E-beam unit. This unit is made up of the following components: an electron accelerator, a scanner, a contact chamber, and lead shielding. The electron accelerator is capable of generating an accelerating voltage of 500 kV and a maximum beam current of about 42 mA, which results in a maximum accelerator power rating of 21 kW. A pyramid-shaped scanner deflects the E-beam, causing the beam to scan the surface of the water as it flows through the contact chamber located beneath the scanner. Lead shielding surrounds the E-beam unit to prevent emission of x-rays. Also, a titanium window separates the scanner from the contact chamber to allow a vacuum to be maintained in the scanner. The E-beam significantly heats the titanium window, which is cooled by air recirculated through the contact chamber. The air is conditioned by a cooling air processor.

Waste Applicability: The E-beam technology is applicable for treatment of volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs) in liquid wastes, including ground water, wastewater, drinking water, and landfill leachate.

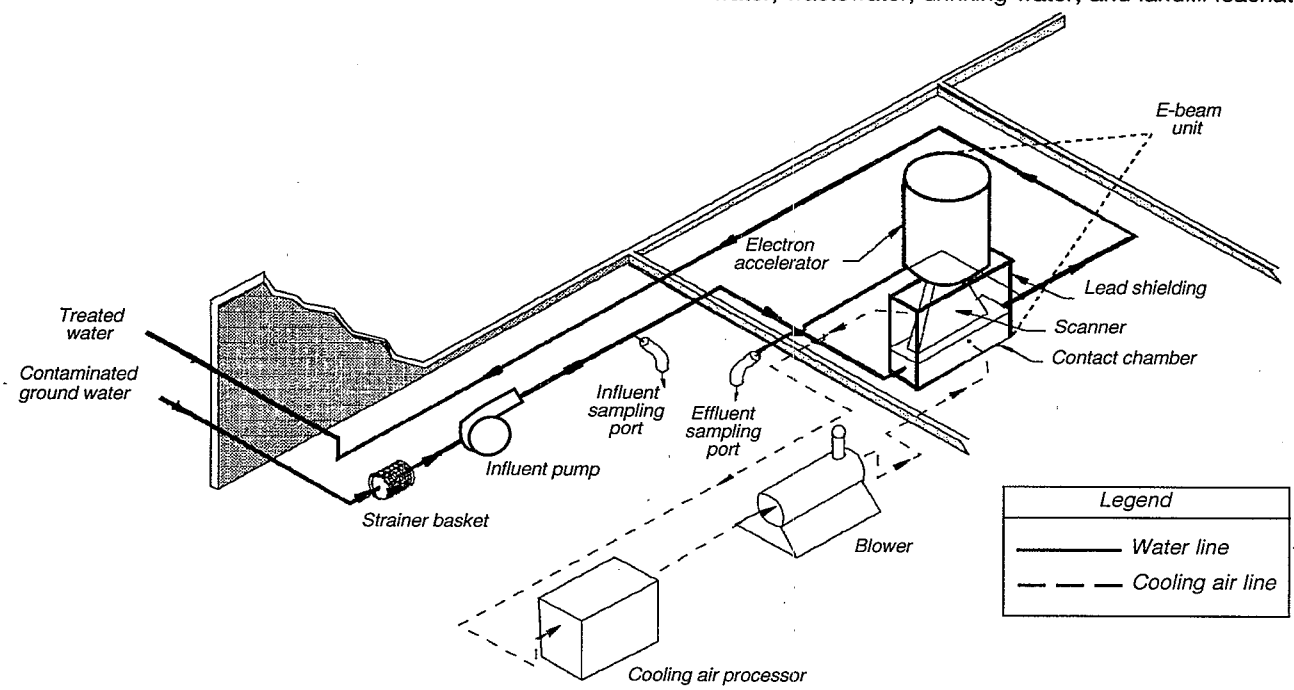

Figure 1. *HVEA E-beam treatment system schematic.*

Demonstration Approach: The E-beam technology was demonstrated at the U.S. Department of Energy Savannah River Site in Aiken, SC, during two different periods totaling 3 weeks in September and November 1994. During the demonstration, the E-beam system treated about 70,000 gal of M-area ground water contaminated with VOCs. The principal ground-water contaminants were trichloroethene (TCE) and tetrachloroethene (PCE), which were present at concentrations of about 27,000 and 11,000 micrograms per liter (µg/L), respectively. The ground water also contained low levels (40 µg/L) of cis-1,2-dichloroethene (DCE).

Thirteen test runs were performed to evaluate the HVEA treatment system. Of these, four runs used unspiked ground water and nine runs used spiked ground water. Toward the end of the demonstration, HVEA adjusted the influent delivery system to enhance treatment system performance. One of the four unspiked ground-water runs and two of the nine spiked ground-water runs were performed using the improved delivery system.

During the spiked ground-water runs, the ground water was spiked with 1,2-dichloroethane (DCA); 1,1,1-trichloroethane (TCA); chloroform; carbon tetrachloride (CCl_4); and aromatic VOCs, including benzene, toluene, ethylbenzene, and xylene (BTEX). These compounds were chosen either because they are relatively difficult to remove using technologies such as the E-beam that employ free radical chemistry (DCA, TCA, chloroform, and CCl_4) or because they are common ground-water contaminants (BTEX). The influent concentrations of these spiking compounds ranged from 100 to 500 µg/L.

During the demonstration, ground-water samples were collected at the E-beam system influent and effluent sampling locations, and cooling air was sampled as it entered and left the cooling air processor. Ground-water samples collected during all runs were analyzed for VOCs and pH, and ground-water samples collected during selected runs were analyzed for SVOCs, haloacetic acids, aldehydes, hydrogen peroxide (effluent only), total carbon, total organic carbon, purgeable organic carbon, total organic halides, chloride, alkalinity, and acute toxicity. Cooling air samples collected during nearly all runs were analyzed for VOCs, ozone (O_3) and hydrochloric acid (HCl).

Demonstration Results: Key findings of the SITE demonstration, including sample analytical results, will be discussed in detail in the innovative technology evaluation report and the technology evaluation report. The results will also be summarized in a demonstration capsule and a videotape. During the SITE demonstration of the E-beam technology, the following preliminary findings were made:

- In general, the highest VOC removal efficiencies (REs) were observed in improved delivery system runs. The highest REs observed for TCE, PCE, and DCE were 99.5%, 99%, and greater than 91%, respectively. The REs for chlorinated spiking compounds ranged from 68% to 98%, and REs for BTEX ranged from 88% to 99.5%. However, the effluent did not meet Safe Drinking Water Act maximum contaminant levels.

- In the tests performed to evaluate the effluent's acute toxicity to water fleas and fathead minnows, less than 50% of the organisms survived.

- VOCs, O_3, and HCl were detected in the air entering the cooling air processor and returning to the E-beam unit. For example, VOCs, O_3, and HCl were present in the air entering the cooling air processor at levels up to 5.7, 22.8, and 0.3 parts per million by volume (ppmv), respectively. Similarly, VOCs, O_3, and HCl were present in the air returning to the E-beam unit at levels up to 4.3, 16.2, and 0.2 ppmv, respectively.

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